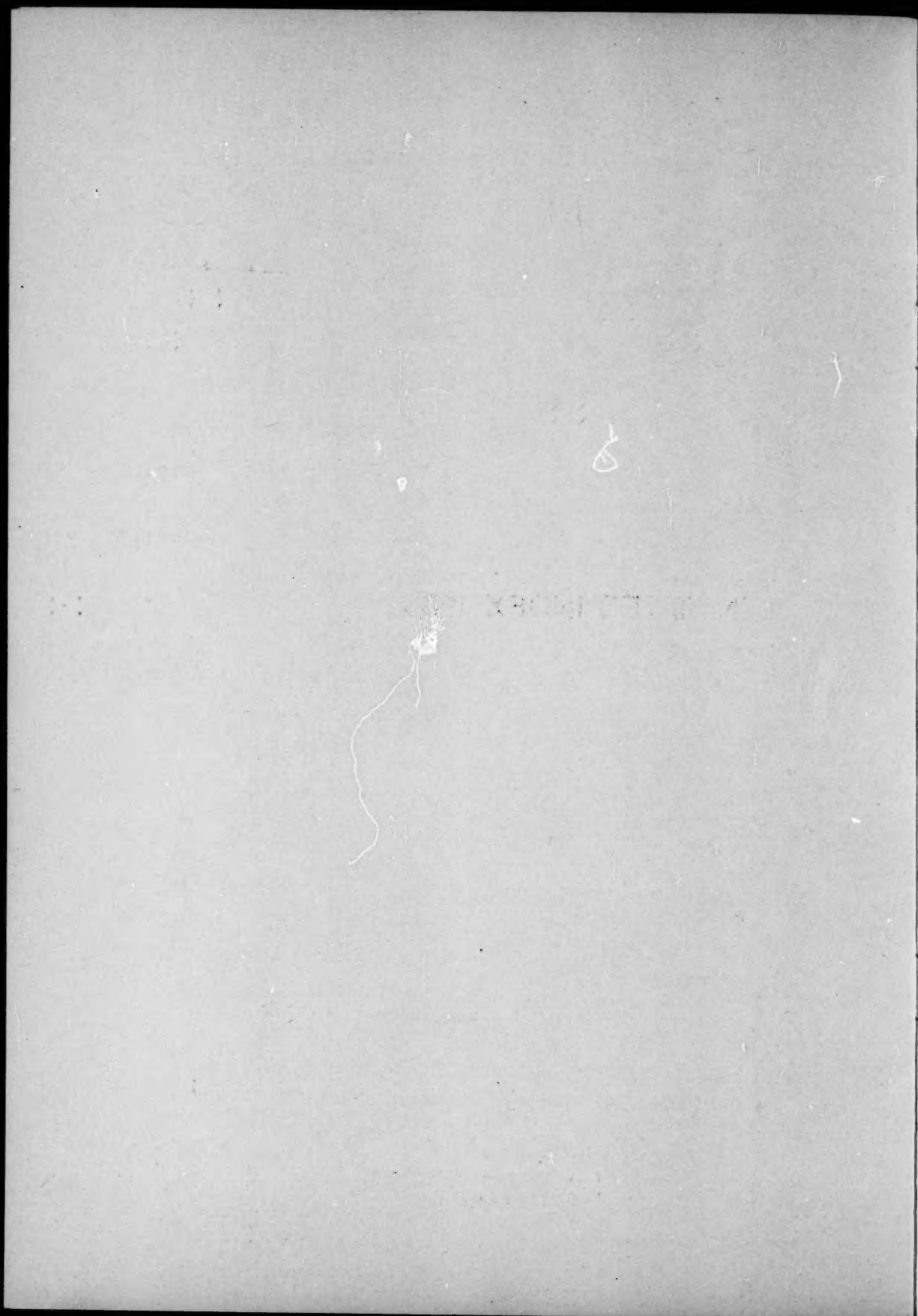


ACTA POLYTECHNICA SCANDINAVICA

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ABSTRACTS

CHEMICAL TECHNOLOGY AND METALLURGY SERIES

(formerly Chemistry including Metallurgy Series, ISSN 0001-6853)

Ch 160

UDC 66.047

Imakoma, H., Okazaki, M., and Toei, R., *Mathematical Model for Drying of Adsorptive Porous Materials*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 160, Helsinki 1985, 32 pp. ISBN 951-666-208-0. ISSN 0781-2698.

This paper presents a mathematical model for drying of adsorptive porous material. The model contains no parameters which are to be determined by drying experiments, and can simulate the variation of total pressure generated in the body during drying at a temperature under the boiling point of water.

Experimental and simulation results are given for an activated alumina rod. The present model can satisfactorily predict the moisture content profiles and the generated pressure changes with time at the constant temperature of body during drying.

Ch 161

UDC 669.35:669.054

Kojo, I.V., *The Thermodynamics of As, Sb, Cu, Bi, Pb, Ni, Se, Te, and Sn in the Fire-Refining of Copper by Sodium Carbonate Slag*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 161, Helsinki 1985, 48 pp. ISBN 951-666-211-0. ISSN 0781-2698.

Distribution equilibria of antimony, arsenic, copper, bismuth, lead, nickel, selenium, tellurium, and tin in the system copper-sodium carbonate were determined as a function of the oxygen activity of the melt. Arsenic and antimony are fluxed as pentavalent cations, antimony being, however, fluxed as a trivalent oxide at lower oxygen activities. Tin, selenium and tellurium are removed as tetravalent cations in oxidizing conditions. Bismuth exists in the flux as a trivalent species, whereas lead and nickel form bivalent and copper monovalent cationic species. At reducing conditions, below an oxygen partial pressure of about $10 \exp(-8)$ bar, selenium and tellurium in the slag form bivalent anionic species with the stoichiometries of Na_2Se and Na_2Te .

The activity coefficients for impurity compounds in the slag were calculated from the experimental distribution data using additional thermodynamic data from literature. On the basis of the activity coefficients, the functions for distribution coefficients were evaluated and used for the optimization of parameters in the copper fire-refining process.

Ch 162

UDC 541.135:541.17:542.87:622.765

Heimala, S., *Investigation of the Electrochemical Processes in Sulfide Flotation*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 162, Helsinki 1985, 63 pp. ISBN 951-666-212-9. ISSN 0781-2698.

Sulfide flotation has been investigated originating from the hypothesis that it could be based on an electrochemical process. Spectrometrical and electrochemical methods have been used to study copper sulfide-kaliumethylxanthate-water, chalcopyrite-kaliumethylxanthate-water and pentlandite-kaliumethylxanthate-water systems. It has been shown that the reactions between the above mentioned metal sulfides and xanthate are chemisorption processes controlled by the electrochemical potential. It was observed that in practice the xanthate chemisorption is not pH dependent.

Oxygen mainly effects the metal sulfide-xanthate reaction on Cu_xS by changing the potential and altering the metal-sulfur ratio on the surface. Iron was found to dissolve preferentially from chalcopyrite and pentlandite which strongly influences the froth flotation of these sulfides.

Ch 163

UDC 669.15:539.389.3:620.17/.18

Kajatkari, M., *The Effects of Aging on the Deformation Behaviour of Fe-Ni-C Plate Martensite*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 163, Helsinki 1985, 60 pp. ISBN 951-666-213-7. ISSN 0781-2698.

The effects of aging on the properties of Fe-18.0Ni-0.71C (wt-pct) plate martensite was studied. Experimental methods included: compression tests, internal friction measurements, differential dilatometry, retained austenite measurements, scanning and transmission electron microscopy. Compression tests were mainly performed at 213 K and 183 K. Deformation structures in virgin and aged martensites were studied using scanning and transmission electron microscopes. Aging temperatures were 293 K and 373 K, and aging times were 100 min and 10,000 min. The reasons for the differences in the strain hardening rates and deformation structures of virgin and aged martensites were discussed.

Ch 164

UDC 66.021.3

Nordén, H.V., Westerlund, L.M., *Calculation of Staged Cascades Using Reference Concentrations*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 164, Helsinki 1985, 36 pp. ISBN 951-666-215-3. ISSN 0781-2698.

In this article, a modification of a calculation method for staged cascades, called the Z-method, is presented. This method of calculating staged mass transfer operations is based on the reference concentration, Z, as in the earlier work of Nordén and Viljakainen, but the definition of the reference concentration differs slightly. Based on a new symmetrical mass transfer equation, the theory is presented and the relationships are derived for ideal and real stages. All side streams are treated as pseudostages in order to

obtain equations formally similar to those of ideal stages. Calculations by this method are demonstrated with two numerical examples. Although the examples concern distillation and absorption calculations, the present method is applicable to other staged mass transfer operations as well.

Ch 165

UDC 66.095.2:66.023:517.957:517.91

Heiskanen, T.H., *Mathematical Model for Continuous Emulsion Polymerization of Vinyl Chloride and Its Steady-State Solution*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 165, Helsinki 1985, 63 pp. ISBN 951-666-217-X. ISSN 0781-2698.

The mechanism and kinetics of vinyl chloride emulsion polymerization as reported in the literature is reviewed and then a mathematical model for continuous emulsion polymerization of vinyl chloride is developed using a population balance and its moment transformation and including nucleation and growth kinetics. Steady-state equations are presented and solved for numerical example.

Ch 166

UDC 678.742:66.095.26

Seppälä, J.V., *Studies on Ethylene Copolymerization with 1-Butene and Long Chain α -Olefins*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 166, Helsinki 1985, 32 pp. ISBN 951-666-221-8. ISSN 0781-2698.

This paper summarizes the results of studies on polymerization of ethylene with 1-butene and long chain α -olefins with Ziegler-Natta catalysts in a slurry polymerization. 1-decene, 1-dodecene and 1 hexadecene were used as long chain α -olefins. The effect of 1-butene addition was investigated. Polymer compositions and basic physical properties were investigated. Polymer composition was measured by carbon-13-NMR spectroscopy and pyrolysis hydrogenation gas chromatography. Basic mechanical properties of the polymers were measured from plate and film samples. The polymerization was characterized by determining the reactivity ratios of the terpolymerization equation. The binary reactivity ratios for ethylene - long chain α -olefin pairs were also determined. The calculated compositions were compared with the analyzed compositions.

Ch 167

UDC 669.332:669.053

Vartiainen, A., *Simulation of Copper Smelting and Slag Cleaning Stages by Laboratory Scale Particle Jet Smelting Technique*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No.167, Helsinki 1985, 88 pp. ISBN 951-666-222-6. ISSN 0781-2698.

The particle jet smelting technique was used to produce from a complex copper concentrate, matte and slag phases in the copper smelting stage, and to study the slag cleaning using products from the oxidation stage as starting material and methane/oxygen gas mixture, copper concentrate or pyrite concentrate as

reductants. In the oxidation stage, oxygen and sulfur contents in the matte as well as copper in the slag were presented as a function of matte grade and compared with equilibrium and industrial values. The distribution of impurities Zn, Pb, As, Sb, Bi was discussed using distribution coefficients between slag and matte phases, and fractional distribution in the gas, slag and matte phases. Generally all impurities were strongly transferred to the gas phase due to the intensive reactions and high temperature in the jet.

The slag cleaning showed that copper as well as ferric iron contents in the slag could be effectively lowered using gas reduction, residue copper contents being at the minimum of about 0.5% Cu in slag. By using copper concentrate or pyrite concentrate treatment in the slag cleaning, the copper content in the slag could be decreased to a final content of 1.0-1.5% Cu in slag. In gas reduction the impurities were almost completely transferred to the gas phase. When metallic copper phase was present, these impurities were also transferred to the metallic copper, the contents depending on the presence of the matte phase between metallic copper and slag.

CIVIL ENGINEERING AND BUILDING CONSTRUCTION SERIES

Ci 83

UDC 624.012.3/.4:628.2

Kinnunen, J., *Loading Pressures on a Concrete Pipe in the Ground, and Loading Capacity of a Concrete Pipe*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 83, Helsinki 1985, 58 pp. ISBN 951-666-201-3. ISSN 0355-2705.

In this study the distribution of the loading pressures on the pipe has been clarified especially according to the element method based on the theory of elasticity also using elasto-plastic law and by means of the computer. The crown pressure for rigid concrete pipes can be from even surface loading and covering earth loading to about 1.5 times the corresponding pressure without the pipe. In the case of line load this ratio for a rigid pipe can be up to 2.3. For rigid pipes the lateral pressure is small. For flexible pipes the crown pressure of the pipe approaches the lateral pressure of the pipe. The loading capacity of a concrete pipe has been clarified theoretically and according to statistics on test loading in practice. Formulae for theoretical loading capacity of concrete pipes have been presented based on the theory of plasticity. The loading capacity of the concrete pipe placed into the ground can be achieved by means of the supportfactors. This article is based on a dissertation for the degree of Doctor of Technology at Helsinki University of Technology.

Ci 84

UDC 624.27:624.072.2

Jutila, A., *The Effect of Bracing on the Behaviour of Double Girder Slab Bridges*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 84, Helsinki 1985, 145 pp. ISBN 951-666-214-5. ISSN 0355-2705.

The effect of lateral bracing, joining the lower flanges of a double girder slab bridge, is examined. The bracing system consists of straight bars, which form shapes like the capitals I, X, IX, K, V, IV and N. The redundant forces of the struts and laterals are obtained by solving compatibility equations using the force method. The examination is based on the theory of simple bending and on that of thin-walled beam-shells with an open cross-section derived by VLASOV. The latter theory is extended with respect to the sectorial coordinate. Departing from the traditional treatment, the symmetrical distortion of the cross-section, and the horizontal curvature of the structure, in some cases even the lateral local bending of the lower flanges, are considered. For symmetrical distortion, a new approximate theory, based on the use of an equivalent solid plate as bracing, is derived, and the mathematical difficulties, due to the presence of lower flanges, are discussed. An extension of the equations derived by KRISTEK and SLAVÍKOVÁ for the asymmetrical distortion of a double tee beam without lower flanges is presented. Finally, the developed method of analysis is illustrated by an example of a bridge and the theoretical values are compared with model test results.

ELECTRICAL ENGINEERING SERIES

E1 55

UDC 621.372.8:535.3

Saijonmaa, J., *Computational Analysis of Realistic Scalar Optical Fiber Modes*. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 55, Helsinki 1985, 27 pp. ISBN 951-666-210-2. ISSN 0001-6845.

This paper summarizes five publications constituting the thesis for the degree of Doctor of Technology. The papers of this work consist of computational studies of light propagation in single- and multimode optical fibers. Light dispersion, excitation and modal noise based on the modal theory of propagation in optical fibers are analyzed in the three first papers. Narrow light beam propagation in elliptical multimode fibers and curvature loss mechanisms in singlemode fibers are analyzed applying the beam propagation method in the two last papers.

MATHEMATICS AND COMPUTER SCIENCE SERIES

Ma 43

UDC 537.874.4:519.63

Rajala, J. and Sarvas, J., *Electromagnetic Scattering from a Plate-Like Non-Uniform Conductor*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 43, Helsinki 1985, 20 pp. ISBN 951-666-199-8. ISBN 0355-2713.

A numerical method has been constructed to compute the electromagnetic fields scattered from a plate-like, non-uniform conductor, i.e. a plate with a finite conductivity which may vary on the plate as a function of position. The plate lies in a homogeneous three-dimensional space. The EM has harmonic time dependence; otherwise it is quite general. If the conductivity of the host medium is very low, then the induced current in the plate is often almost solenoidal and the usual thin plate integral equation does not apply. This problem has been overcome here by dividing the induced current into solenoidal and laminar parts for which new integral equations are derived. The resulting numerical method works for any conductivity contrast between the plate and the host medium. The method is a new result for a non-uniform plate. Also, some numerical examples are presented which were prepared for electromagnetic prospecting purposes, the EM source being a magnetic dipole in the audio frequency range.

Ma 44

UDC 007.52:534.2:681.5.015

Kärkkäinen, P., *On the Control of Manipulator Flexible Motion by Modal-Space Techniques*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 44, Helsinki 1985, 89 pp. ISBN 951-666-204-8. ISSN 0355-2713.

A method for compensating manipulator flexibility effects to cope with the current requirements for better accuracy and higher performance of manipulator motion is introduced. A modal approach is used for obtaining the reduced order mathematical model of the manipulator flexible motion which is sufficiently tractable to be utilized in control purposes. The arm model is represented by a state space description defined in terms of the model displacements and velocities obtained from truncation on the distributed parameter system.

The control of the manipulator vibrational motion is examined via the linearized model around the operating configuration defined by the joint coordinates. The optimal feedback control law based on independent mode space is derived suppressing the vibrations.

Both the analytical tools and experimental modal analysis are applied to finding the equations of motion of a particular manipulator. The flexible motion is approximated by a few discrete coordinates. The motion equations are used to investigate the interaction between the control system and the flexible components of the manipulator arm. The use of the modal controller developed in the compensation of the arm structural flexibility is demonstrated both by simulations and experimental tests. The results indicate practical application for improved manipulator control schemes.

Ma 45

UDC 681.3

Karonen, O.J., *Geometric Mine Modeling: Modeling of Three-Dimensional Objects Based on Incomplete Information*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 45, Helsinki 1985, 77 pp. ISBN 951-666-205-6. ISSN 0355-2713.

The applicability of advanced modeling, search and statistical methods to mine design has been explored. The central problem considered is how to estimate the shape, location, mass and metal grade of an orebody using mainly drill core samples. Fully automatic solutions giving satisfactory results are extremely difficult to put into practice. Instead, the geologist's intuition and efficient tools together are a successful combination. The solution is to use sections, triangulation and block conversion. The borders of an orebody are determined on section planes. The surface between consecutive planes is interpolated by a set of triangular faces wrapped around the sections. Ore estimation is performed by converting this boundary representation into a collection of rectangular parallelepipeds, which are analyzed using geostatistical methods (kriging). The solution makes it possible to estimate reliably the mass and metal grade of an orebody in a few minutes. A prototype system has been implemented on top of a general solid modeler. The realization of a production version of the system has already started.

MECHANICAL ENGINEERING SERIES

Me 89

UDC 519.63:621.039.5

Siikonen, T., *Numerical Simulation of Hydraulic Transients*. Acta Polytechnica Scandinavica, Mechanical Engineering Series No. 89, Espoo 1985, 28 pp. ISBN 951-666-209-9. ISSN 0001-687X.

A numerical method suitable for the analysis of hydraulic transients in one-dimensional pipelines as well as some applications of the method are presented in this thesis. In the present method one-dimensional flow equations are solved in a characteristic form using a finite difference technique. A non-equilibrium two-phase flow model is used, which makes it possible to analyze the effect of vaporization. The motion of the pipe-wall, which is important in some types of hydraulic transients, can be taken into account approximately. The main application of the method has been the piping of nuclear reactors.

Me 90

UDC 531.01

Bazley, N.W. and Brüll, L., *Periodic Solutions of an Averaged Duffing Equation*. Acta Polytechnica Scandinavica, Mechanical Engineering Series No. 90, Helsinki 1985, 11 pp. ISBN 951-666-207-2. ISSN 0001-687X.

A new method for describing the qualitative behaviour of T-periodic solutions

($T=2\pi n$, $n \in \mathbb{N}$) of the Duffing equation $y'' + y - \frac{1}{6}y^3 = \sin t$. Our procedure is to approximate by the averaged system $y'' + (1-\alpha)y = \sin t$, $\alpha = \frac{1}{6T} \int_0^T y^2(s) ds$; here, it is possible to calculate explicitly all T -periodic solutions. Elementary analytic number theory is used to determine their asymptotic; the results are further compared with existing methods for quantitative approximations. Comparison is made with an exactly resolvable case.

Me 91

UDC 621.436:620.179.13:536.2

Juva, A.P., *On the Development of Methods for Estimating Thermal Loading in High-Speed Diesel Engines*. Acta Polytechnica Scandinavica, Mechanical Engineering Series No. 91, Helsinki 1985, 156 pp. ISBN 951-666-220-X. ISSN 0001-687X.

In this study, the thermal loadings of a turbocharged high-speed direct injection diesel engine are experimentally investigated. The effects of engine load and of changes in the settings on the cylinder wall temperatures and on the different phases of the heat transfer into the coolings are determined. In this study, in most cases the total heat input of one cylinder is used as quantity characterizing the engine load. It is an expedient quantity in comparisons between different engine types regarding their thermal loadings.

Two approaches to temperature extrapolation are presented. They may be used to determine, for instance, the temperatures corresponding to overload condition without any heat damage risk incurred owing to the measurements. The first approach is based on the presumption that the temperature change corresponding to a given change in total heat input is linearly dependent on the temperature at the point under consideration. The other approach is based on measured temperature effects caused by given changes in conditions.

APPLIED PHYSICS SERIES

Ph 148

UDC 531.44:685.363:551.322

Spring, E., Pihkala, P., and Leino, M.A.H., *An Apparatus for the Measurement of Friction on Ice and Snow*. Acta Polytechnica Scandinavica, Applied Physics Series No. 148, Helsinki 1985, 12 pp. ISBN 951-666-200-5. ISSN 0355-2721.

A friction meter consisting of a rotating table, diameter 1.0 m, on which the test object glides, is described. The friction and normal forces acting on the test object were measured by a piezo-electric force gauge, i.e. a load cell. For measurements of friction on ice and snow, the meter was placed in a freezer. Thus measurements could be made in the temperature range -20 to $+20$ °C and the velocity range 0 to 13.5 m/s. Both static and kinetic friction coefficients for different ski soles and different waxes on snow and skate blades on ice were determined. The accuracy of the measurements was 2 to 5%. The apparatus can, in principle, be used for friction measurements with all kinds of solid materials.

Ph 149 and Ph 150

UDC 778.3:681.3:535.3/.6

Friberg, A.T. and Oittinen, P. (eds), *IMAGE SCIENCE '85*. The proceedings of Image Science '85 Conference, Helsinki, Finland, 11-14 June 1985. Acta Polytechnica Scandinavica, Applied Physics Series No. 149, Helsinki 1985, XVIII + 328 pp (Vol.1), and No. 150, Helsinki 1985, XVII + 292 pp (Vol.2). Volume 1 ISBN 951-666-202-1; Volume 2 ISBN 951-666-203-X. ISSN 0355-2721.

The proceedings deal with the principles and applications of optical and digital image science. Among the principles there are included holography, imaging methods, components and systems, considerations of image quality, image processing, image coding, storage and transmission, and image analysis. Holographic and medical applications, statistical optics, tomography, satellite imaging, imaging in robotics, robot and human vision, and acoustical imaging are contained in the applications.

Ph 151

UDC 550.837.6

Aittoniemi, K., Hirvonen, M.T., Rajala, J., Sarvas, J., and Soikkeli, J., *Broadband Electromagnetic Measurements over Conductive Orebodies and Their Interpretation with Heterogeneous Plate Models*. Acta Polytechnica Scandinavica, Applied Physics Series No. 151, Helsinki 1985, 39 pp. ISBN 951-666-206-4. ISSN 0355-2721.

Time-harmonic electromagnetic measurements in the field for geophysical ore exploration using controlled transmitters are reviewed. Particular attention is paid to the problems of obtaining reliable results in the frequency range 0.2 Hz to 10 kHz. The types of transmitters and sensors, the measurement setup and the data processing are described. Studies of two conductive dikes, one containing metal sulphides, the other graphite schists are reviewed. In each case the results of the broadband measurements are interpreted in detail in terms of a plate model. A very satisfactory agreement is reached between the experimental and theoretical results. The principal conclusions emerging from the interpretations concern the depth extents and the distributions of the conductivity-thickness products of the dikes. In both cases the minimum depth extent consistent with the experimental results exceeds the verified by drilling. The conductivity-thickness product increases with depth in both dikes. In the graphite dike a minimum in the conductivity-thickness product is observed in the strike direction, in agreement with earlier investigations. The need for broadband measurements exploration is discussed.

Ph 152

UDC 620.039.56

Leikkonen, I., *Methods for Optimal Spatial Control of Pressurized Water Reactors*. Acta Polytechnica Scandinavica, Applied Physics Series No. 152, Helsinki 1985, 106 pp. ISBN 951-666-196-3. ISBN 0355-2721.

The total power and the power distribution in the core of a pressurized water reactor are controlled with soluble boron in the cooling water, with control rods, and in some cases with the temperature of the cooling water. The beha-

viour of the reactor core in the time scale of hours is determined in a large extent by xenon-135 and iodine-135. Methods and goals for optimal spatial control of the core in daily operations are discussed. The control is subject to some constraints, such as limits on the maximum power density and the rate of control movements.

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ACTA POLYTECHNICA SCANDINAVICA

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